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[54] **INTERFEROMETRIC TEMPERATURE SENSING SYSTEM HAVING A COUPLED LASER DIODE WHEREIN THE MAGNITUDE IS ADJUSTED CORRESPONDING TO A PRIOR FEED-BACK LASER BEAM**

[75] Inventors: **Kyung-Shik Lee**; **Yun-Hae Yeh**, both of Kyungki, Rep. of Korea

[73] Assignee: **SamSung Electronics Co., Ltd.**, Kyungki-do, Rep. of Korea

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **356/345**; 374/131; 374/162; 356/43; 356/44

[58] **Field of Search** 356/43, 44, 345, 356/350, 352; 374/130, 131, 160, 162

[56] **References Cited**

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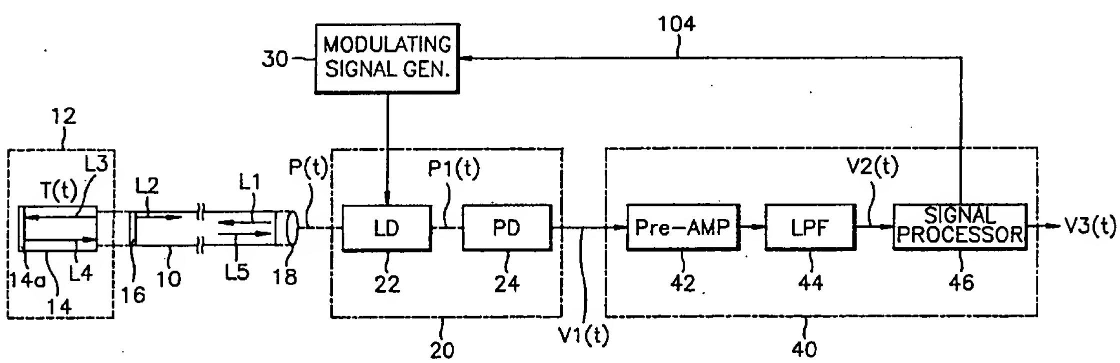
Primary Examiner—Samuel A. Turner
Assistant Examiner—Robert Kim
Attorney, Agent, or Firm—Robert E. Bushnell

[57] **ABSTRACT**

An interferometric temperature sensing system provides a simplified design for accurately processing an interference fringe pattern using self coupling effects of a laser detection element, where a laser diode and an optical detection element are combined in one package. Accordingly, the present invention is easily made and the measurement of temperatures within a wide range can be easily performed. The interferometric temperature sensing system contemplates an interferometric sensor having one or more reflecting surfaces and different optical paths corresponding to a temperature of a measured object or environment; a laser detection element for emitting a first laser beam in response to a predetermined modulated driving signal and adjusting the amount of the emitted first laser beam corresponding to a second laser beam, the laser detection element also detects the magnitude of an adjusted third laser beam to generate a sense signal that includes temperature information; an optical coupler for propagating the emitted first laser beam to a proximal end of the interferometric sensor, coupling the laser beams fed back through the proximal end of the interferometric sensor into the second laser beam, and then propagating the coupled beam to the laser detection element; a modulated signal generator for generating the modulated driving signal in response to a predetermined pilot signal; and a temperature processor for generating the pilot signal, and detecting a temperature change direction and a fringe number of the sense signal to calculate a temperature change.

38 Claims, 6 Drawing Sheets



INTERFEROMETRIC TEMPERATURE SENSING SYSTEM HAVING A COUPLED LASER DIODE WHEREIN THE MAGNITUDE IS ADJUSTED CORRESPONDING TO A PRIOR FEED-BACK LASER BEAM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application makes reference to, incorporates herein, and claims all benefits available under 35 U.S.C. §119 through our earlier filing of a patent application for Interferometric Temperature Sensing System Having A Coupled Laser Diode filed in The Korea Industrial Property Office on 31 Dec. 1993 and assigned Ser. No. 1993/31806.

BACKGROUND OF THE INVENTION

The present invention relates to a temperature sensing system, and more particularly to an interferometric temperature sensing system that uses a laser detection element to measure a temperature by detecting changes in an interference fringe pattern indicative of changes in external temperature.

A thermocouple or resistive temperature detector (i.e., RTD) is typically used for general methods of electrically measuring the temperature of heat-emitting objects, objects within a hot environment or an ambient temperature of a hot (i.e., beyond room temperature) environment. Temperature measuring meters using such above methods have problems however, with electromagnetic interference (EMI), accuracy, response speed, and resolution. Also, there is a problem in that high temperatures are not easily measured. To solve many of the problems associated with the above mentioned temperature measuring means, an interferometric temperature measuring method has been developed.

The interferometric temperature measuring method uses an interferometric sensor formed on the end of an optical fiber. Temperature is measured by detecting variances in an interference fringe pattern between two laser beams within the sensor having different paths. Such an interference temperature measuring method is disclosed in Optics Letter, Vol. 17, No. 14, pp. 1021 in an article entitled SAPPHIRE FIBER BASED INTRINSIC FABRY-PEROT INTERFEROMETER by Ando Wang. Another interference temperature measuring method is disclosed in U.S. Pat. No. 4,714,342 filed on Dec. 22, 1987 by David Jackson. These references show that a change in an interferometric fringe pattern generated within the interferometric sensor can be detected by using electronic equipment including a single-mode fiber directional coupler and a photo diode. Once the degree of change in the interferometric fringe pattern is determined, a corresponding temperature can be calculated.

In contemporary practice, a laser beam emitted from a laser generation source is transmitted to one side of the single-mode fiber directional coupler and reflected back onto the other side. The light is then detected in a photo diode connected to the opposite side of the single-mode fiber directional coupler. The light detected by the photo diode is converted into a corresponding temperature by an electronic circuit. These techniques typically use items such as a single-mode optical fiber, a single-mode fiber directional coupler, a laser diode, an optical detection element, or a temperature conversion circuit, among other circuit components.

An optical temperature sensing system composed of these components may detect an amount of change in interference light generated within the sensor, i.e. the change in the interference fringe pattern as described above by using the photo diode is converted into a corresponding temperature using an electronic circuit.

Contemporary available devices often use interferometers having different structures. The optical temperature sensor introduced by Wang, et al. uses an interferometric sensor having a Fabry-Perot structure. The Fabry-Perot interferometric sensor produces variations in phase difference between two laser beams having different reflecting paths, corresponding to the temperature. On the other hand, the interferometric temperature sensor disclosed in U.S. Pat. No. 4,714,342 issued to Jackson uses an interferometric sensor having a Michelson structure. That is, Jackson's sensor varies the phase difference between two laser beams respectively reflected onto a signal optical fiber and a reference optical fiber, according to the temperature.

Both of the devices described above transmit interfering light from an interferometric sensor to a photo diode using a single-mode fiber directional coupler. In response, the photo diode converts a sensed signal into an electrical signal that is signal processed to determine a measured temperature. Implementation of such conventional interferometric temperature sensing methods is not easy. Such methods are plagued by many difficult problems. Also, since expensive optical elements such as a single-mode fiber directional coupler is required for implementation, practical use of such devices and methods is limited.

One more recent effort to create an interferometric device is disclosed in U.S. Pat. No. 5,202,939 entitled Fabry-Perot Optical Sensing Device For Measuring A Physical Parameter issued to Belleville et al. on 13 Apr. 1993. This device uses a Fabry-Perot interferometer through which a light signal is passed, an optical focusing device for focusing at least a portion of the light signal outgoing from the Fabry-Perot interferometer, and a Fizeau interferometer through which the focused light is passed. A multimode optical fiber optically couples the Fabry-Perot interferometer with a light source. Although this effort purports to achieve satisfactory results during operation, we find that many of the aforementioned problems regarding cost and ease of implementation are still present.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved interferometric temperature sensing system and process.

It is another object to provide an interferometric temperature sensing system and process that can be easily implemented.

It is yet another object to provide an interferometric temperature sensing system and process that measures temperature using an optical detection element using a laser beam emitting element and an optical detection element for converting a laser beam fed back from a sensor into an electric signal, that may be fabricated within a single package.

It is still another object to provide an interferometric temperature sensing system and process able to easily measure a temperature using a laser detection element composed of a laser diode coupled to a photo diode, without using a single-mode fiber directional coupler.

To achieve these and other objects, the interferometric temperature sensing system and process performed according to the principles of the present invention uses an inter-